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ABSTRACT

Computers have the power to make drastic changes in modern life and in education particularly. It is uncertain, however, how smoothly computers can be integrated into society and into the schools. The speed of the growth of computer technology is often referred to as a revolution, with a constantly increasing ability to store and recall information and solve problems at lower and lower costs. The major impediments to the introduction of computers into schools are teachers' hostility and lack of knowledge. Computer education is best aimed at preservice teachers. This can be done through a "saturation" approach, through special courses added on to the curriculum, or by integration of the computer into existing courses. There are three ways microcomputers can be integrated into education: computer awareness, computer managed instruction, and computer assisted instruction. Computer assisted instruction can be divided into several categories: drill and practice, tutorial, simulation, information retrieval, and problem-solving. Computers can be used in each kind of mathematical problem-solving, including understanding strategies, translating words into symbols, forming mathematical models, developing deductive thinking, improving decision-making, appreciating mathematical skills, and developing mental and logical skills. Examples of computer applications to each kind of problem-solving conclude the paper. (Author/JM)

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Microcomputers and Problem Solving

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INTRODUCTION

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

The simultaneous increase in capacity with reduction of cost has led to a virtual computer revolution. For public schools and for the nation as a whole this revolution represents an opportunity to involve computers in education. There is serious doubt, however, as to whether we can seize this opportunity or whether, as with educational television, the opportunity will be wholly or partly wasted. One authority (Molnar 1978-79) refers to the present situation as "The next great crisis in American education."

We can take it as a given that modern computing has the potential to drastically alter and improve the way we do many things and is especially relevant to the issue of productivity (Molnar 1980). We can take it as given that computers will affect the life of every individual indirectly and, increasingly, individuals will have direct interaction with computers or computer-guided systems on the job. We can take it as given that the computer can be used to improve instruction and dramatically increase the productivity of teachers. Computers will be the "manipulatives" of the "new" math of the 1980's.

What is not so certain is the realization of this kind of future scenario. Will the integration of computers into society occur smoothly because citizens of the future have a high degree of computer literacy? Will there be an adequate pool of manpower to capitalize on computer applications

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in diverse fields? Will schools meet these goals and other more traditional goals of education by fully utilizing computers in instruction?

The Computer Revolution

In the last few years the microcomputer movement has evolved to play a viable role in education. This movement can be compared to other forms of technology. For example, it took 35 years from discovery of the vacuum tube in the 1880's to the development of a practical radio. The x-ray tube took 18 years to develop, television evolved in 12 years. The nuclear reactor took 10 years to develop, the atomic bomb a mere 6 years. Computer technology growth can be thought of in exponential fashion and is often referred to as a revolution.

The first generation computers were characterized by the use of vacuum tubes. These 1946-1959 computers could do about 40,000 additions per second at a cost of \$1.25 per 100,000 computations. The second generation was brought about due to the invention of the transistor. These 1959-1964 computers could do about 200,000 additions per second, and the cost had dropped to 25¢ per 100,000 calculations.

The third generation, capable of performing 1,250,000 computations per second, was stimulated by the invention of integrated circuits. These 1965-1977 computers could do 100,000 computations for 10¢. Large scale integration marked the beginning of the microcomputer, or fourth generation. These machines could do over 10,000,000 additions per second at a cost of less than 1¢ per 100,000 computations. And, looking toward the future, Hewlett-Packard announced in February of 1981, the development of a chip that can process the information of 1000 books in a single second. This computer chip has a 450,000

transistor capacity. As can be seen, the growth is exponential. From 1950 the capacity per add time in seconds with a computer was around 10^8 , 1960 was 10^{12} , 1970 was 10^{16} and today's models make those seem "turtle slow."

In layman terms, this revolution can be characterized with the following analogy. If the same improvements had followed the production of the first Rolls Royce, you could buy a Rolls Royce today for \$2.75. You could drive this Rolls Royce 2 million miles on a single liter of gasoline and six would fit on a pin head.

Microelectronic technology is constantly increasing our ability to communicate, understand complex problems, store and recall large amounts of information, and create knowledge at lower and lower costs. These lower costs are making technology-aided instruction economically feasible.

INVOLVING MICROCOMPUTERS IN EDUCATION

The involvement of microcomputers in education does not seem to be due to a lack of awareness. The National Council of Teachers of Mathematics (1980) recommended that computers be integrated into all levels of the education system. Progress in this direction seems slow (when compared, for example, with progress in the medical field). Johnson (1980) reports the results of several surveys on computer usage in higher education which show that such use is low overall and especially so in education. Departments of education ranked last by a considerable margin in dollars spent on computing and in students enrolled in computer-oriented courses. This is alarming in view of the fact that teachers will bear the major part of the burden of fostering computer literacy and preparing students to enter computer-related post-secondary training. This finding is even more alarming when one considers that a major impediment to the introduction of computers into schools is the lack of knowledge about

computers, and the outright hostility of practicing teachers towards the new technology (Cogen 1979).

The Arizona State University College of Education recently carried out a survey of computer-usage in all Arizona School districts (Bitter 1980). The majority of those who responded (less than 50%) claimed to be using computers, and for a variety of purposes -- as an aid to instruction and management, to provide computer literacy and to train students for computer-related jobs. The level of awareness seems high and plans are afoot but actual use is very sparse. For example, 37% of the responding districts reported using microcomputers in instruction. But this percentage does not seem so high when one considers that 45% of the 76 microcomputers were located in a single district. Lack of equipment is clearly a problem in Arizona and elsewhere (Chambers & Bork 1980, Johnson 1980) but this does not appear to be the major obstacle. Careful purchasing policies permit a school district to gradually augment its stock of microcomputers without making an appreciable dent in the annual budget. School boards appear to be willing to give serious consideration to the purchase of microcomputers inasmuch as the drill-and-practice capabilities of CAI are in perfect accord with the "back-to-basics" movement. One school district has been successful in acquiring microcomputers from local private business firms. Parent groups are providing microcomputers in many instances. Thus, prediction that 74% of all school districts will be using computers in instruction by 1985 (Chamber & Bork, 1980) seems very realistic.

A second obstacle also appears to be under concerted attack, namely instruction-related software. At a recent conference 55 individuals and 19 commercial concerns displayed or described instructional programs, in what was largely a local effort. Nationally, the field is becoming increasingly

crowded. A recently compiled instructional software vendor's listing for microcomputers had over one hundred entries. In the very near future teachers will have access to a range of materials appropriate to a variety of instructional goals at all grade levels.

THE TEACHER AND MICROCOMPUTERS

Teacher acceptance and knowledge of microcomputers will do a great deal to guarantee their successful use in schools. But, rejection of or inability to utilize computers guarantees failure. Furthermore, the transformation of teaching practice must occur in a very short time span. Not because microcomputers will lose their promise in the future but because "education experiments" have had a shorter time span within which to prove themselves in recent years. If an innovation fails to take hold within a few years, community and school interest wanes, federal funding is curtailed, and so on.

There is a growing body of literature (reviewed by Shavelson 1980) on teaching practices which suggests that teachers begin the year with a plan for instruction and deviate very little from that plan during the year or from year to year. In-service instruction has an impact if it helps teachers do a better job of what they're doing already. It is not an appropriate avenue for introducing major changes in practice such as those represented by a balanced computer-assisted instruction program. Reason dictates that computer education may best be aimed at pre-service teachers. Since their patterns of teaching are not yet established, they ought to be reasonably open to new techniques. Several models can be used for preparing teachers to use computers in their classroom. One such model is the saturation approach used at Dartmouth. It is highly likely that pre-service teachers forced to interact with computers on a daily basis and in all facets of their college career would handle CAI with ease and enthusiasm.

A second model involves the creation of special courses to teach students the use and functions of a microcomputer. However, it is reasonably certain that this model will have only a limited impact. It will be limited for three reasons. First, only those students with a prior interest in computing usually take these courses. Second, the undergraduate-level courses are offered in only one department and very little cross-departmental study takes place, thus cutting down further on potential students. In fact, at the present rate, less than 1% of the teacher graduates will have taken one of these courses. Finally, because the courses are "add-ons" there is little, if any, demonstrable effect. That is, students are learning how to use the computer in isolation from the other knowledge and skills they will acquire in "content" and "methods" courses. It may be too much to expect them to link what they have learned about the computer with what they will learn about educating the learning disabled child, for example.

A third model for preparing teachers to use computers in instruction aims at integrating the computer into existing courses for pre-service teaching. Links between the computer and particular educational problems and practices can be made explicit. This model aims at spreading computer indoctrination out among departments, courses and students. It aims at functional computer literacy, agreeing with Papert (1979) that learning to program a computer is not sufficient or even necessary training for teachers; rather they need to understand what computers can do and how to use the expertise that is already available in hardware and software to attack immediate problems in their own classrooms.

THE STUDENT AND MICROCOMPUTERS

In essence, there are three areas of microcomputer application involving the student in education. They are commonly referred to as computer awareness, computer managed instruction and computer assisted instruction. The following is a general discussion of each area.

Computer Awareness

Computer awareness is the ability to identify a computer and its role in society, its application to the world around us, and to use it reasonably well. The following outline describes a computer awareness curriculum for education (Bitter 1981).

Computer Awareness Topics

- I. Computer Capabilities
 - A. Science fiction discussion
 - B. Actual capabilities (speed, accuracy and repetitiveness)
- II. History of the Computer
 - A. Abacus - 3000 BC
 - B. Pascal - first mechanical adding machine - 1642
 - C. Babbage - mechanical computer - 1830
 - D. Hollerith - developed punched cards - U.S. Census - 1900
 - E. Analog Computer - 1931
 - F. Mark I - first general purpose computer - 1944
 - G. ENIAC - 1945
 - H. Werner Von Braun - computer technology
 - I. IBM - 1959
 - J. Cost
- III. Computer Generations
 - A. Vacuum tube (first) - 1946
 - B. Transistor (second) - 1959
 - C. Integrated Circuit (third) - 1964
 - D. Large Scale Integration (fourth) - 1978
 - E. Very Large Scale Integration (fifth)
- IV. How a Computer Works
 - A. Input
 1. Types (terminal, CRT, cards, paper tape, cassettes, disk)
 2. Accessing a computer
 - B. Output
 1. Types (terminal, CRT, graphic, paper, cassette, disk)

- C. Arithmetic Unit
 - 1. Binary Arithmetic
 - D. Central Processing Unit (CPU)
 - E. Memory
 - 1. Types (disk, magnetic tape, magnetic core)
 - 2. ROM, RAM
 - F. Software - Hardware
 - 1. Languages
 - 2. Stored program
 - 3. Parts of a computer
 - G. Searching, Sorting, Deleting and Updating
- V. Computer Types
- A. Computer Systems
 - B. Mini Computer
 - C. Micro Computer
 - D. Time Sharing Computers
 - E. Microprocessors
 - 1. Uses
- VI. Home Computer
- A. Types
 - B. Applications
 - 1. Passive
 - 2. Active
- VII. Computer Uses
- A. Society
 - 1. Banking
 - 2. Department stores
 - 3. Medicine
 - 4. Law enforcement
 - 5. Government
 - 6. Weather prediction
 - B. Education
 - 1. Computer assisted instruction
 - 2. Computer managed instruction
 - 3. Computer extended instruction
 - C. Data Processing
 - 1. Data Bases
- VIII. Computer Misuses
- A. Fraud
 - 1. Examples (stealing money and information)
 - B. Identification codes, pass words and data files
 - C. Detecting computer-based crimes
 - D. Privacy (credit checks)

- IX. Computer Experiences
 - A. What is a Computer
 - B. Compare to human solving addition problem
 - C. Flowcharting
 - D. Using a Computer
 - 1. Running programs
 - 2. Programming
- X. Computer Careers
 - A. Computer Operator
 - B. Key punch or Coding
 - C. Programmer
 - D. Systems Analyst
 - E. Computer Scientist
 - F. Artificial Intelligence
- XI. Future and the Computer

As can be seen, only the topic of Computer Experiences requires the actual use of a computer. The other topics involve research and discussion related to the computer.

Computer Managed Instruction

Computer managed instruction capabilities can include student attendance, student scheduling, student records and student progress. Individual student plans and schedules can be prepared with a computer managed system. Gradebook record keeping can be an integral part of each program. Many instruction programs include built-in management systems where the computer keeps a record of when and how often a student takes each test, the scores, the material covered, dates signed on and the like (Hodges 1981). Several major publishers now market sophisticated computer managed instruction systems for education. Training is usually required to adequately operate a computer managed system.

Computer Assisted Instruction

Computer assisted instruction can be characterized with the following categories: drill and practice, tutorial, simulation, information retrieval,

and problem solving. Only problem solving requires the user to be able to program a computer.

Drill and practice is the most common microcomputer application. Many commercial programs are available in many subject areas. In fact, any novice programmer can easily develop simple programs of this type.

Tutorial microcomputer instruction is very expensive to develop. This computer assisted instruction involves actually teaching a specific concept. Graphics and sound are helpful to make the presentations meaningful. These programs require an average professional development time of 90 hours for one hour of actual instruction. This area holds much promise for education.

Simulation activities are unlimited. The "Lemonade Stand" is a popular example. This activity provides the user an opportunity to run a lemonade stand with the computer providing many decision alternatives. Presently the simulation developments are more commercial and game-oriented. But, educational possibilities are limitless.

The ability to retrieve information from networks, cable television or telecommunications via satellite utilizing a microcomputer has unlimited potential for education. Cable television is growing very rapidly. There were one million users in 1980, a number which is expected to grow to 30 million by 1982. Interactive video disk and video text capabilities make this an option with a lot of exciting potential for education.

The last CAI application is problem solving. The National Council of Teachers of Mathematics in the 1980 Agenda for Action, included as its first recommendation that, "Problem solving be the focus of school mathematics in the 1980's."

Problem solving with the microcomputer involves the ability to control the machine. Therefore, programming a microcomputer in its own language is essential. The most popular language today is BASIC. PASCAL, another language, also has much potential.

Problem solving was defined in the California framework with seven general descriptions. Using these descriptions as a guide, the following discussion gives suggestions of utilizing the microcomputer as a problem solving tool.

Problem Solving Descriptions

I. To develop an understanding of a broad range of strategies.

Problems which require the strategies of guessing, estimating, experimenting, graphing, formulas, etc., can all be explored with the computer.

Example:

$$\text{Formula } A = P(1+i)^n$$

Suppose interest is earned at 6% per year, compounded semiannually. Find the total amount of interest earned on \$225 deposited for 3 years. Students program the computer to solve the problem. Experiment with different options and estimate the results to determine if answer is realistic.

Example:

Compute π as a decimal from:

A. Formulas:	Egypt	1800 BC	The Rhind Papyrus used $(\frac{4}{3})^3$ for π
	Greece	150 AD	Ptolemy used $\frac{377}{120}$ for π
	India	510 AD	Aryabhata $\frac{62832}{20000}$ for π

B. Series:

$$\frac{\pi}{4} = 1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \frac{1}{9} \dots$$

$$\frac{\pi^2}{6} = 1 + \frac{1}{2^2} + \frac{1}{3^2} + \frac{1}{4^2} + \dots$$

$$\frac{\pi^2}{8} = 1 + \frac{1}{3^2} + \frac{1}{5^2} + \frac{1}{7^2} + \dots$$

Discuss accuracy of answers as well as the different methods.

Other strategies which can be applied with a microcomputer are tables and graphs.

II. To translate words into mathematical symbols.

Students can take word problems and write programs to solve the problem. A major microcomputer task is to learn to program the computer. This is a problem solving experience of communicating with the machine in the language it understands.

Example 1

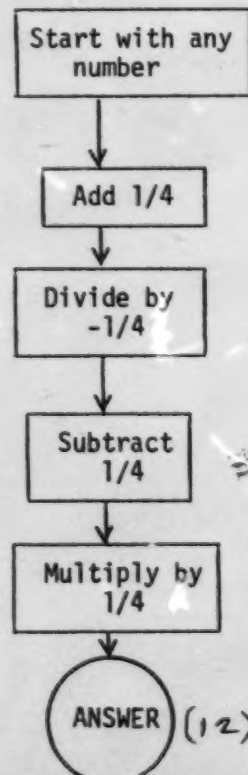
What number am I?

CLUES Divide me by 20
 The quotient is 36
 The remainder is 14

Write a program to solve this problem

Example 2

What is the answer



Write a program to carry out the steps of this flowchart.

III. To form mathematical models from real world situations.

Many applications can be placed into this category.

Example:

Find the total bolts of wallpaper needed to cover the inside of a room including the ceiling.

In this case the computer program should include the ability to subtract window and door spaces. Encourage using INPUT statements, so that the program can solve the problem with no program revision necessary.

IV. To develop deductive or convergent thinking skills.

Programming a computer involves logical reasoning, an excellent way to develop problem solving abilities.

Example 1:

Write a program to simulate the sieve of Erathosthenes. This problem involves deductive planning skills.

Example 2:

Find the sum of the first N numbers. The formula or logical sequence method can be applied using a computer program.

V. To improve and enhance decision making skills.

Consumer "best buy" problems and applying certain conditions to problems can improve these decision making skills.

Example:

Which is the best way to buy:

51¢ 6 oz.	99¢ 1 lb. 2 oz.	\$2.39 2 lb. 8 oz.	\$1.89 1 lb. 13 oz.	84¢ 1 lb. 4 oz.
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Writing a general computer program will help students make decisions on detecting the best buys. A metric equivalent example would also be meaningful.

VI. To motivate students to learn and appreciate certain mathematical skills.

Interesting problems can motivate students to solve problems. Sports, music, cooking, etc., are areas of interest.

Example:

American League Standings

<u>Eastern Division</u>	<u>Wins</u>	<u>Losses</u>
Baltimore	36	21
Boston	34	21
Milwaukee	32	27
New York	31	27
Cleveland	27	28
Detroit	25	26
Toronto	16	42

Develop a program to print out the standings allowing daily updates.

VII. To develop mental and logical skills, related to creative and divergent thinking.

The computer has certain BASIC program commands which enhance this ability. Writing programs with loops, IF THEN statements, counter ($I = I + 1$) and sums ($X = X + Y$) require that the student think in computer logic, rather than in the logic of general mathematics.

Example 1:

Flow Charting

Example 2:

Simulations with random capabilities

Tossing coins

Rolling dice

Choosing at random a card

Example 3:

Prediction by representing situations graphically

Pollution

Smoking

Odds

Example 4:

Looping to show repeated processes

Tree growth

Interest accumulations

These are some problem solving experiences which the computer can enhance. This microcomputer educational option is potentially the most significant in terms of problem solving.

CONCLUSION

Trained teachers, software, awareness and applications are the keys for successfully introducing microcomputers into education. Future developments in graphics, sound or speech synthesis capabilities, home information systems and voice recognition will improve the potential of microcomputers in the classroom.

Hopefully, education can take full advantage of this microelectronic revolution and actively utilize the potential in the classroom to teach children and adults.

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